

Biodiesel Terminology

- · Biodiesel-fuel made from vegetable oils or animal fats
- Alcohol- any carbon chain which includes an -OH group
 - Methanol (MeOH) or Ethanol (EtOH)
- Catalyst- a substance that is used in a chemical reaction, but not consumed
 - Potassium or Sodium Hydroxide (KOH or NaOH)
- FAME- <u>Fatty Acid Methyl Esters</u> (<1 g/mL)
- B100-100% biodiesel
- · B20-20% biodiesel, 80% traditional diesel
- · Glycerin- co-product of biodiesel

Vegetable Oil Sources

- In the U.S., most biodiesel is made from soybean oil or recycled cooking oils
 - Typically collected as waste oil from restaurants
 - Restaurants pay to have it removed, but you remove it for free: everybody wins!
 - Times are changing, though, and waste oil is getting expensive (regionally dependent)
- Animals fats, other vegetable oils, and other recycled oils can also be used to produce biodiesel
- Blends of all kinds of fats and oils may be used to produce biodiesel

Catalyst Choice



- Potassium Hydroxide (KOH)
 - Most used by homebrewers
 - Dissolves faster as flakes than NaOH pellets
 - Glycerin produced can be easily made into liquid soap
- Sodium Hydroxide (NaOH)
 - Typically causes more complications with soap formation
 - Used more in the industry
 - Glycerin produced can be easily made into bar soap
- Both have a high pH (caustic)
- · Both are dangerous- can burn skin, eyes, respiratory system

Alcohol Choice

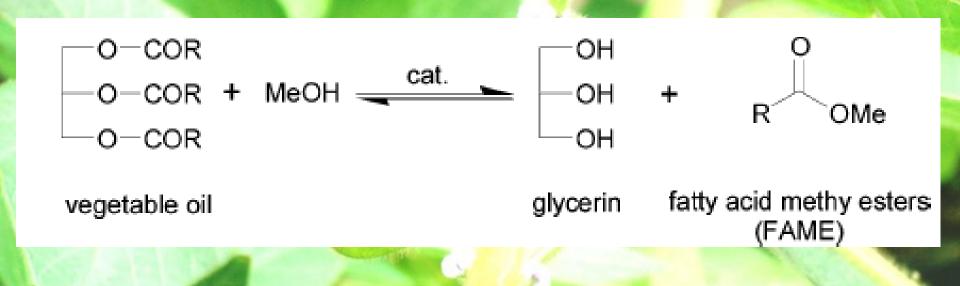
- · Methanol (MeOH)
 - Most used by both homebrewers and in the industry
 - Biological effects similar to consuming ethanol, but more severe
- Ethanol
 - More restrictions on purchasing, storage and use
 - Higher rate of complications in reaction
 - Can cause inebriation
- · Both highly flammable and must be respect
- · Store only as much as you need in a safe (FLAMMABLE
 - Obey local fire codes



Oil Quality

- Titration- used to measure the amount of Free Fatty Acids in used or virgin oil
 - Higher titration means more catalyst needed to convert
 - Can be performed at oil collection site
- Water testing- oil MUST be water-free to react properly
 - Qualitative Heating Test (Crackle test)
 - Centrifuge Test
 - Water can be removed by heating or settling

FAME Equation "Fatty Acid Methyl Ester"



"Dr. Pepper" Method

Single-Stage Process

- · Is typically used before a large batch
- Results indicate how well the method will work on this specific oil
- Must be done in the lab, not at oil collection site
- Takes 12-24 hours for results

- Performed in glass Mason jars
 - MeOH will start to eat plastic after 24-36 hours

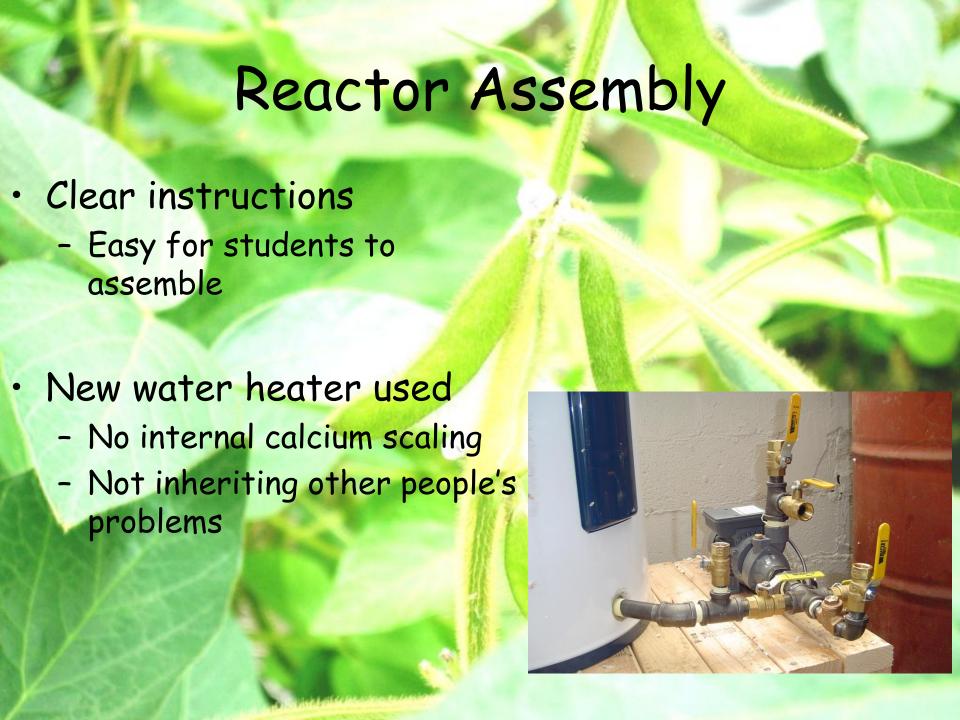


Appleseed Processor

- Plumbing w/ Pump ~\$550
- 120V Water Heater ~\$400
- · Lumber ~\$25
- No plumbing experience needed

- All new parts used
- Costs can be reduced by salvaging/recycling





Methods Summary

- %MeOH needs to be at least 13%
 - More MeOH ensure greater completion of reaction
 - Too much can be wasteful, though

- Circulation times can vary
 - 1-3 hours per batch seems to work for most

 Batch sizes of 100L used for simplicity in calculations (scaling up or down)

Glycerin Removal

Drain the bottom layer of glycerin

- · Dr. Pepper Method
 - Invert pop bottle and gently squeeze while using your thumb as a valve
- It is better to overflow and lose some biodiesel, than to leave some glycerin in your biodiesel



Water Washing (optional)

- Mist washing- a fine mist of water onto surface of biodiesel
 - Water needs to be small droplets and hit the surface at a low velocity
- Drain water as misting continues
 - Water droplets pick up impurities on their way through the biodiesel
- Fuel will eventually get clear as water drains out
- Turn off water and allow the fuel to settle
- Water is a contaminant in biodiesel and is sometimes difficult to remove





Quality Testing 3/27 Test

- Tests for triglycerides (unreacted oil)
 - Does not for monoglycerides and diglycerides
- Tells you if you must reprocess
- Add 1 part biodiesel to 9 parts methanol in a sealable vial (3mL & 27mL, etc.)
 - Be very precise with measurements if using these small amounts
- Look for particles in the vial and/or cloudiness
 - If present, your sample failedreprocess
 - Sample should be clear to pass



Biodiesel Storage

- · Biodegradable in months to years
 - Less time than table sugar
 - No research to support this claim
- Only make as much as is needed
- Hydroscopic (attracts atmospheric water)
- More glycerin falls out over time, regardless of draining or filtering
- Fire code regulations

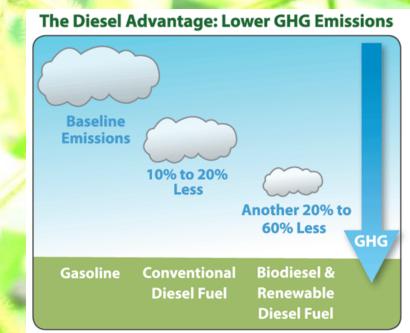


Biodiesel Use Cautions

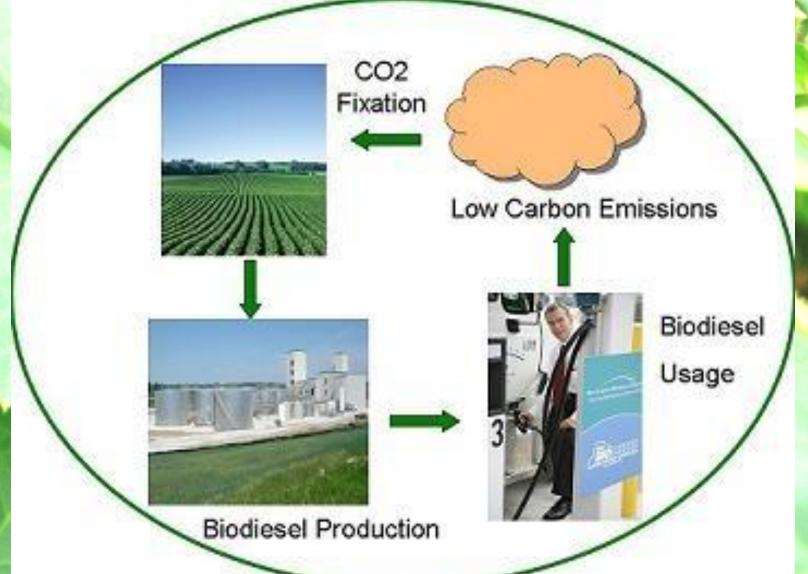
- · Biodiesel as an excellent solvent
 - All natural rubber will eventually be dissolved
 - Use Viton, or other synthetic rubber hoses, seals and gaskets
 - Breaks down petroleum "grit" that builds up over time in the combustion chamber
 - · Grit is dissolved by biodiesel and can clog fuel and exhaust filters
 - Starting with a lower % of biodiesel slows this process
 - Can increase % over time while replacing rubber material and filters

Benefits of Biodiesel

- Operates in conventional diesel engines
- Does not require special storage
- Exhaust is less offensive
 - Smells like food that it was used for
- Safer to use than dino-diesel
- Reduced greenhouse gases emissions
 - 30-80%, depending on %B
- Improves domestic energy security



Closed-Carbon Cycle



Glycerin Co-Product

Soap (1L batch)

- Remove the residual (toxic) methanol first
- KOH-based biodiesel makes liquid soap glycerin
 - NaOH-based production makes bar soap
- At 50°C, preheat any of the following ratios before mixing for 5 minutes

GlycerinWater	33mL 7mL	47mL 5mL	54mL 5mL

 Can not use KOH and NaOH interchangeably

- Fragrances and dyes can be added
 - D-limonene smells like oranges and is cheaply made/purchased
 - Most dyes muddy the dark brown color



Cross-Curricular Opportunities for Biodiesel & Soap

- · Art Class
 - Dispensing Container Design
 - Brand name & Label graphics
- Economics
 - Cost Analysis of Biodiesel & Glycerin Soap
 - Marketing of product
- · Fundraiser

Web Resources

- blatham.multiply.com
 - Personal biodiesel website
- www.localb100.com
 - For small scale producers
- utahbiodieselsupply.com
 - Produce, Promote and use Biodiesel
- journeytoforever.org/biodiesel.h
 tml
 - Information & tutorials
- · www.biodiesel.org
 - National Biodiesel Board
- www.spill911.com
 - Safety, Spill Containment & Industrial Supply
- www.mcmaster.com
 - Industrial equipment

- www.globalindustrial.com
 - Material Handling Equipment
- www.bloomhs.org
 - Bloom High School, Chicago Heights, IL
- www.biodieselcommunity.org
 - Collaborative Biodiesel Tutorial
- www.ucsusa.org
 - Union of Concerned Scientists
- Biodiesel America.org
 - Resources, Information, Community & News
- www.B100Supply.com
 - Appleseed Reactor
- www.graingercom
 - Industrial equipment

Funding Information

- A+ for Energy \$40,000 awarded for 2007-2010 by BP, Inc.
 - Biodiesel, Photovoltaic Power, Fuel Cell, Wind, Efficiency projects
 - Ethanol Research, Alternative Energy Fairs
- \$2,500 awarded 2006-2009 by Bloom Foundation
 - Analytical balances for research lab
 - Supplemented purchase 6.5kW (bio)diesel generator
 - Momentum carts for physics course
- \$3,500 Earth Day Network awarded October 2008
 - Field trip to Eco-House at Museum of Science & Industry
 - 1982 Mercedes Benz 300SD Turbo Diesel
- \$5,000 DonorsChoose.com awarded April-December 2008
 - Digital Video camera, Molecular models, LCD Projector
 - Model rockets, Soap making supplies

Grants, 1

- A+ for Energy
 www.aplusforenergy.com
- Earth Day Network
 www.earthday.net
- Donors Choose
 - www.donorschoose.com
- American Honda Foundation
 - corporate.honda.com/america/philanthropy.aspx?id=philanthropy_overview
- National Science Teachers Association
 - www.nsta.org/academy/2009/FellowApplication.aspx
- Bristol-Meyers Squibb
 - www.bms.com/responsibility/grantsandgiving/medical_science_education/Pa ges/default.aspx

Grants, 2

- Motorola Enterprises Mobility Business and Symbol Technologies
 - www.symbol.com/category.php/?category=736
- Toshiba
 - www.toshiba.com/tafpub/upload/page/100045/25964_Executive pdf
- The Charles A. and Anne Morrow Lindbergh Foundation
 - www.lindberghfoundation.org/grants/index.php
- Albertson's
 - www.albertsons.com/abs_inthecommunity/
- Green School Project
 - greenschoolproject.com/default.aspx
- · Jewel-Osco
 - <u>www.jewelosco.com/eCommerceWeb/CommunityAction.do?action=beginCommunity</u>